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GROWTH RATE AND AGE AT SEXUAL MATURITY OF ATLANTIC SALMON SMOLTIFYING AGED ONE AND TWO YEARS

By
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ABSTRACT

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Post-smolt growth rate and age at first maturation are compared for sib groups or population groups of salmon originating from Norwegian rivers and fish farms. Generally, high correlations were found between corresponding values (lengths at different ages and proportions of mature fish in the second and third sea years) for one and two year-old smolt. One year-old smolts were smaller than the two-year olds at the smolt stage and grew slower during their first sea year, but the two categories reached practically the same total length after two years in the sea. In most groups, and in the total material, one year-old smolts gave higher proportions of grilse. Proportions of mature fish during their third sea year were similar for one and two year-old smolt of the same groups. Pronounced variations between sib groups and population groups were found both in growth rate and mean age at first maturation. This variation was much bigger than the variation between one and two year-old smolts of the same sib group.

INTRODUCTION

In Norwegian rivers salmon normally smoltify at 2–5 years-old, depending upon the environmental factors in the rivers, and probably on genetic factors as well (REFSTIE, STEINE and GJEDREM 1977). In commercial rearing of smolt, one year-old smolts are commonly obtained by using heated water, offering good food supply and grading away the smallest individuals after one summer. In Norwegian fish farms about 2/3 of the smolt are now reared in one year and the rest in two years.

It has been widely discussed whether the fast pre-smolt growth rate and early smoltification have some influence on the subsequent growth rate and age at first sexual maturity of the fish. RITTER (1975) and RITTER and NEWBOULD (1977) found significantly lower proportions of grilse in groups of one year-old smolt than in groups of two year-olds or older smolt. Fish farmers have observed that two year-old smolt grow faster and are easier to handle than one year-old smolt the first weeks or months in the sea.

However, most observations suffer from the drawback that fish of different genotypes have been observed. The observations reported here were made on one and two year smolt of the same sib groups, ensuring that similar genotypes could be compared.

MATERIALS AND METHODS

The parent fish in the present investigations were collected from seven rivers and two fish farms in Norway in autumn 1973. Normally two males and two females from each locality were used. The egg portion from each female was divided into two equal parts, each of which was fertilized with sperm from one of the males, thus giving four groups of full sibs from each locality (eight groups from one of the localities).

During fresh water stages the experiments were performed at the Akvakulturstasjonen Matre research station. The eggs and fish were kept in separate trays and parr tanks until they were about six months old (September 1974). Thereafter the groups were kept together two by two in the tank after removing the adipose fin of the fish in one of the groups. In May 1975 the one year-old smolt were marked with freeze-branding (REFSTIE and AULSTAD 1975) and transferred to sea water and later in the summer to the fish farm of Svanøy Stiftelse (Svanøy Foundation), Svanøybukt. The rest of the fish were transferred to brackish water (15–20ppt) in net pens outside the research station in late summer. The next spring (May 1976) nearly all fish smoltified, and after freeze-branding they were transferred to Svanøy Stiftelse. An outbreak of *vibriosis* reduced the number of one year smolt drastically, and many of the groups could not be used in further comparisons. During the sea water stage the fish were length-measured after one year, and at one and a half years, and were slaughtered after about 24 months in the sea. Maturing fish were recorded during the second sea year, and whether or not the fish matured during the third sea years was recorded at slaughtering.

The aim was to select parent fish for the second generation based on the results of the measurements, in order to obtain genetic improvement for fish farming. However, this could not be done because IPN virus was detected in material belonging to the experiments.

The two year-old smolt of the year class hatched in 1973 were kept in similar net pens to the one year smolt at Svanøy Stiftelse, and data from the 1973 year class have therefore been used for comparison.

Standard statistical methods were used for calculations of correlation factors. Per cent values were transformed to $\sin^{-1}\sqrt{\text{proportion}}$ before calculations. Comparisons of corresponding values for one and two year-old smolt were based on the sib groups, but where the numbers of one year-old smolt within groups were low, the sib groups from the same locality were pooled.

RESULTS

GROWTH RATE

Fig. 1 shows main results concerning growth rate. Marked differences between groups were observed.

The mean lengths at the smolt stage were somewhat greater for the 2 year-old smolt than for the one year-old smolt, and after one year in the sea the mean lengths were considerably greater for the 2 year-olds than for the one year-old smolt. For instance, the total mean for the 2 year-old smolt was 42.5 cm against 35.5 cm for the one year-old smolt. However, during the second sea year this difference nearly disappeared, and in many groups the one year-old smolt were larger than the 2 year-old smolt at the end of the second summer. The total mean then showed a difference of 1.7 cm in favour of the 2 year-old smolt. Six months later the two categories were nearly of the same size.

The results were also compared to the mean of the 1973 year class which was composed of 2 year-old smolt and was reared in pens parallel to the one year-old smolt of the 1974 year class. The results of the two year-old smolt of the two year classes were very similar (Fig. 1).

Mean lengths for one and two year-old smolt of the same groups were subjected to a correlation analysis. The following correlation coefficients were found:

smolt:	0.14
one year in the sea:	0.75
one and a half years in the sea:	0.71
two and a half years in the sea:	0.75

Except for the first one, these coefficients are highly significant ($p < 0.01$), implying that each groups has its characteristic post-smolt growth potential regardless of whether they smoltify after one or two years.

AGE AT FIRST SEXUAL MATURATION

The proportions of mature fish observed during second (grilse) and third sea years are shown in Fig. 2. Considerable variation was observed between sib groups and locality groups. Most groups showed higher proportions of grilse among the one year-old smolt than among the two year-old smolt, and the total mean of the one year-old smolt amounted to 23% against 15% for the two year-old smolt. In relation to maturation during the third sea year, good correspondance was generally observed between one and two year-old smolt of the same groups, although some groups diverged somewhat. However, it should be noted that the values of the one year smolt especially are based on few individuals, and rather high sample variation

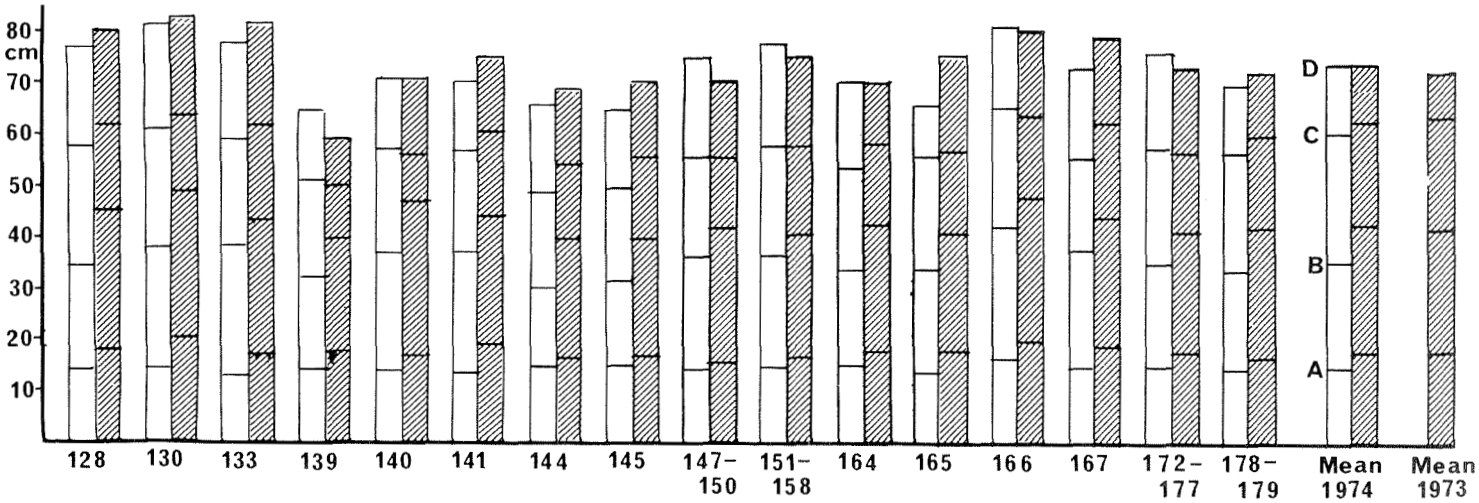

Fig. 1. Mean length of salmon sib groups as smolt (A), after one year (B), after one and a half years (C) and after two years in the sea (D).
Open histograms: one year-old smolt; hatched histograms: two year-old smolt.

may exist. Totally, the two year-old smolt showed a somewhat higher proportion of mature fish during the third sea year.

Corresponding values of one and two year-old smolt of the same groups were subjected to a correlation analysis. The proportions were transformed to $\sin^{-1} \sqrt{\text{proportion}}$ before calculations. The following correlation factors were found:

Maturation second sea year:	0.81
Maturation third sea year:	0.64

Both factors are highly significant ($p < 0.01$), and they show that on an overall basis there is very good correspondance between the results of the two categories. Age at maturation (after smolt stage) thus seems to be a characteristic trait of the groups, although there is a tendency towards higher proportion of grilse among one year-old smolt than among two year-old smolt of the same group. Compared to the two year-old smolt of the 1974 class, both categories of the 1974 year class showed lower proportions of mature fish in both their second and third sea years. This, however, was expected because the 1973 year class contained several groups of a typical grilse population.

DISCUSSION

Differences in post-smolt growth rate between one and two year-old smolt the first sea year was expected, because of the smaller initial size of the one year-old smolt. However, concerning growth rate, one and two year-old smolt are evidently of about the same value for fish farming as they reach the same mean size at the normal time of slaughtering.

The effect of parental age on age at first maturity in Atlantic salmon has been observed by different authors (PIGGINS 1973, RITTER and NEWBOULD 1977, NÆVDAL *et al.* 1978). Genetic factors seem to be very important in determining the age at which the salmon are destined to mature. In the present study considerable variation between sib groups and populations was found, confirming the results of previous studies.

Higher proportions of grilse were observed among one year-old smolt than among two year-olds in most groups, and in the total material. This is somewhat in contrast to the findings of RITTER and NEWBOULD (1977) who found proportionally fewer grilse among one year-olds than among two year-old smolt. The reason for this discrepancy is unknown, but it seems reasonable that different populations may behave differently also in this respect.

HALLINGSTAD (1978) found higher proportions of early maturing rainbow trout among the faster growing than among the slower growing individuals. The fastest growing fish were mostly males, and it is well known that most of

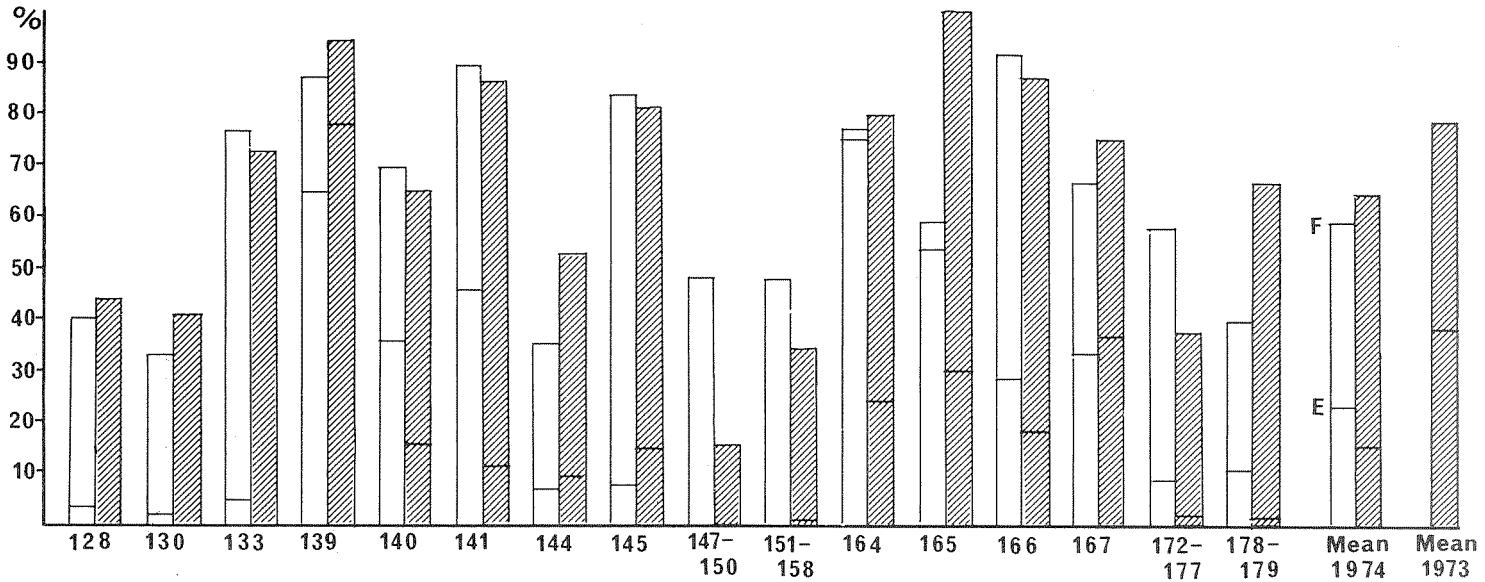

Fig. 2. Proportions of salmon sib groups maturing during their second (E) and third year in the sea (F). Open histograms: one year-old smolt; hatched histograms: two years-old smolt.

the early maturing rainbow trout are males. A similar explanation could not be applied to the present results because the distribution of sexes was nearly the same for the one and two year-old smolt.

One year-old smolt are those fish showing the higher pre-smolt growth rate. If high pre-smolt growth rate causes, or is connected with increased likelyhood of early maturation, or if the fish destined to mature early also show high pre-smolt growth rates, the differences between one and two year-old smolt may be explained. The present experiment can not answer this question, but for practical fish farming it would be important to know if high pre-smolt growth rate also gives high proportions of early maturing fish. If this should be the case, the use of one year-old smolt in fish farming should be questioned.

However, the difference in maturation age between one and two year-old smolt was much smaller than the difference between populations. In some populations there were nearly no grilse, regardless of age of smolt, and selection of such populations for farming could therefore probably solve the problem with grilse among farmed salmon.

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